

**EFFECT OF ANT - RADIATION AGENTS ON SURVIVAL, HAIR, AND SKIN
EMBEDMENT OF MALE AND FEMALE MICE EXPOSED TO TWO LETHAL DOSES
OF WHOLE BODY GAMMA RADIATION****Hussain Al – Wandawi^{*1}, Hala H. Kareem², Etidal E. Mahdi², Laith H. Kareem³, Homam I. Abdulrahman⁴**¹Al-Mamoon University, College. of Pharmacy, Baghdad, Iraq.^{2,3}Al-Turath University, Baghdad.

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ABSTRACT

The natural amino acid, 5 – Hydroxytryptophan (5 – HTP) is intermediate metabolite of the essential amino acid tryptophan (Trp). Both 5 –HTP and Trp are precursor of a neurotransmitter serotonin (5 –tryptamine (5 – HT), often called the happiness hormone for its crucial role in regulating mood, sleep, appetite and digestion. In humans. There are two sites for serotonin synthesis, the gut provides approximately, 95 % of total body serotonin, most of which exists in plasma, and acts as a hormone, primarily regulating gut functions like gut motility, while the other site is the neurogenic neurons in the brain. The brain uses both tryptophan and 5 – hydroxytryptophan as precursors for serotonin synthesis because both can cross brain blood barrier (BBB), while serotonin found in the plasma cannot pass BBB. Although both Trp and 5 – HTP can cross the brain blood barrier “BBB” and reach the neurogenic neurons in brain where serotonin can be synthesized ,however, 5- hydroxytryptophan is generally recommended over tryptophan because it crosses the” BBB” at higher rate with minimum competition with the branched amino acids. In this study, using mice as widely used and well accepted animal model for such kind of study, the anti-radiation potential of different concentrations of 5 – HTP, alone and in combination with very low and nontoxic concentration of a sulfhydryl compound, S (2 - amino ethyl) isothiuronium bromide hydrobromide (AET) on survival, hair, and skin embedment. Significant encouraging results were obtained regarding survival, hair and skin health in treated animals. Moreover, successive administration three folds of this combination within an hour unwanted effects on survival, hair and skin embedment were observed 30 day after treatment.

KEYWORDS: Effect of 5- HTP alone and in combination with non-toxic dosage of AET on; survival, and skin health of male and female mice exposed to lethal whole - body doses of gamma radiation.**INTRODUCTION**

The concern regarding acute radiation syndrome (ARS) has steadily grown since the massive causality observed among civilians during nuclear attacks on Hiroshima and Nagasaki, on 6 and 9 August, 1945). The subsequent nuclear events like Chernobyl nuclear disaster (26 April 1986) and Fukushima nuclear accident 11 March 2011 have intensified the global worry. Although, intensive researches have been conducted during the past seven decades no antiradiation agent for mass radiation casualties has not been approved by US FDA. In all these cases, there is continuing concern about the massive exposure among civilians and early responders,, including firefighters, and nuclear workers were exposed

to large doses of gamma radiation, consist of high energy photons, emitted and could penetrate body tissues and cause damage to cells and their genetic materials(Nenot, 1996, Gomes,1999, UNSCEAR, 2008, WHO, 2011, Tanaka, 2012, Gudkovs et al., 2015, Haworth, 2016, Micewicz (ARS) et al., 2019, SIPRI2023, 2025). In Chernobyl nuclear reactor accident, 237 people on site were initially suspected of having acute radiation syndrome (ARS), also known as radiation sickness; a condition of health effects that are caused by being exposed to high amount of ionizing radiation - more than 0.1 Gy (100 mSv or 10 rad)) in short period of time. Twenty - eight out of 237 died within the first three months due to high radiation doses. The 134 individuals

with ARS received whole body doses of 0.8 – 1.6 Grays (8,000 and 1,000 mSv). No radiation medical countermeasure (MCM) for acute radiation syndrome is currently available. Bone – marrow transplants were done in more severe cases, but the results were largely disappointing (Guskova et al, 1986). Many others were affected from long – term effects and subsequent death. The first responders, including firefighters, and nuclear workers were exposed to large doses of gamma radiation., which consist of high energy photons, are emitted and could penetrate body tissues and cause damage to cells and their genetic materials.

MATERIALS AND METHODS

Animals

Male and female mice used in study, were progeny of BALB /c inbred. They were born within a barrier, reared within comfortable controlled conditions (ambient temperature 25 ° C; $\pm$ 2 ° C, 8 hours' dark and 16 hours' light; and they were kept; weaned at the age of 21 days and the males were separated from the females, and they were kept usually five a cage mates were sibs, but sometimes came from different litters; there was no fighting. The animals were allowed free access to a standard pellet –diet, and tap water (potable water) was provided add labium. At the beginning the animals were 10 - 12 weeks old and the females were weighting 18 -21 gm. and the males 21 -26 gram. Every effort was tried for keeping the animals under comfortable and hygienic conditions.

Chemicals

The chemicals, 5-HTP and AET were obtained from Fluke AG, Buchs, Switzerland and used as supplied. All other chemicals were of Analar grade and obtained from BDH, Poole, England.

Preparation of 5 – hydroxytryptophan (5-HTP) and AET(S-2-aminoethyl) isothiuronium bromide Dihydrobromide

Aqueous solutions of 5-HTP and AET were prepared either alone or as combination (when required to be injected as a mixture). The solutions were usually sterilized by filtration using Nalgene sterilizing unit type-5 (pores diameter; 0.2 μ m) obtained from Nalgene Company, Rochester (USA). In all experiments, the amount of AET intraperitoneally injected was fixed at 20 mg / kg mouse body mass, while the amounts of 5-HTP injected were in the range of 25 – 200 mg / kg body mass, and in any case, the total volume injected per mouse was not exceeded 0.5 ml. The above chemical and saline solutions were administered intraperitoneal 20 minutes (unless otherwise stated) before whole body gamma irradiation (WBI) with a Radiation single dose in the range of 800 – 1330 rad (8- 13.30 Gy).

Radiation source A Canadian Gamma Cell – 220 (Atomic Energy of Canada) equipped with ^{60}Co – source at a dose rate 18.20 Gy per minute was used at time when this study was conducted. Dose assessment was

carried out using TLD, Film Badge and Chemical Dose Meters revealed no significant difference between the theoretical and the calculated dose was observed.

Irradiation chamber

A cylinder shape irradiation chamber (Fig.1) was specifically designed to fit the irradiation space of the irradiation system (Canadian Gamma Cell 220). It was made of cross – linked polystyrene polymer (radius; 145 mm, and 4 mm thickness) with five identical partitions made of Perspex cross – linked styrene polymer (radius 145 mm, height 160 mm; thickness 4 mm) with 5 identical partitions made of Perspex material and vertically stacked thus allowing simultaneous irradiation of 5 animals each time. The outer surface of the whole irradiation chamber was uniformly perforated for the comfort of the animals.

Irradiation procedure

A Canadian Gamma Cell – 220 equipped with Co – 60 sources at a dose rate 18.20 Gy per minute was used at time when this study was conducted. Dose assessment was carried out using TLD, Film Badge and Chemical Dose Meters revealed no significant difference between the theoretical and the calculated dose was observed.

Treatments

For each treatment 8 cages (each containing 5 animals) were selected at random so that the total number of animals per treatment was always 40 . As a routine procedure, each animal was placed anaesthetized in the irradiation chamber.

RESULTS SAND DISCUSSION

In this study, using male and female BALB / c mice as well accepted animal model. Photo No.1) shows an irradiation chamber specifically designed to accommodate 5 animals simultaneously and ensure receiving equally and uniformly dose of whole body irradiation. Photo No.1. shows an irradiation chamber specifically designed to accommodate 5 animals simultaneously and ensure receiving equally and uniform dose of whole body irradiation. Photo No.2. shows male and female mice without any treatment, the animals look active with, normal body size, shiny hair and normal skin embedment. Photo No.3. Shows male and female mice intraperitoneally injected with distilled sterilized water to serve as control and photographed 12 - 14 days later. Photo No. 4. Shows male and female mice exposed to 8 and / or 10 Gy gamma radiation, photographed 12 - 14 days after exposure. The animals show the typical marked radiation syndrome, fatigue, their hair is ruffled and the skin embedment is reduced as a result of the general emaciation. Photo No.5. shows male and female mice intraperitoneally injected with combination of 5 – HTP and (100 and 20 mg AET / Kg body weight),15 - 20 minutes before whole body exposure to 8 Gy (photo no.5) or 10 Gy. Photo No.6 of Gamma radiation; and photographed 12 – 14 days after irradiation. It can be seen the animals are active, no sign of weight reduction,

and their hair is shining and smooth. Photo No.6. Shows animal survived the lethal dose of radiation (within the 5% survival) show significant loss in weight at recovery stage, but their hair was smooth and shiny, with no skin of abnormality.

Fig. 1. Shows the effects of different treatments on the survival of mice. It can be seen that that whole body irradiation of mice with 8 Gy Gamma radiation resulted in 95 mortalities on the day 30th after irradiation. Intraperitoneal administration of combination of 5 - HTP 100 mg / Kg mouse body wt. and 20 mg AET/ Kg mouse body wt. resulted in 95 % survival on the day 30th after irradiation. It can also be seen that decreasing the amount of 5 - HTP (in the previous combination) to 25 or 50 mg / Kg mouse body wt. resulted in significant drop in survival accounted to about 40% only. The results presented in Fig. 2 show that whole body exposure of mice to 10 Gy Gamma radiation, induced 100 % mortality on the day 30th after irradiation, all mortality occurred within the first two weeks after irradiation. As early sign of radiation effect, the animals were appeared fatigue, their body hair was ruffled, and showed sign of emaciation (a state of extreme weight loss, severe muscle atrophy, and loss of subcutaneous fat, usually caused by chronic illness (cachexia) or severe malnutrition/starvation). To test the effect of high dosage of this this combination, it injected 3 times intraperitoneally during one hour, no any sign of abnormal findings including survival, weight loss etc. could be seen after 30 days of treatment. Fig.2. also show the intraperitoneal injection of 5 - hydroxytryptophan (100 mg / Kg mouse body weight) 3 times within one before exposure to 10 Gy Gamma radiation resulted in 80 % survival. Increasing the 5-HTP to 200 in combination with 20 mg AET/ Kg mouse body wt. followed by exposure to 10 Gy whole body Gamma radiation resulted in significant drop in survival which was about 50 % as observed on the 30th after irradiation. Fig.3. Shows the effect of variation in AET concentration in combination with a fixed concentration of 5 -HTP on mice whole body irradiated with 8 Gy Gamma radiation. The results show that combination of 20 mg with 100 mg / Kg mouse body wt. resulted in only 5 % mortality on the day 30th after irradiation. Increasing the concentration of AET to 30 mg / kg mouse body improved the survival, while increasing the AET to 75 mg / Kg mouse body wt. has resulted in survival to drop to about 80%. **No.6.** Male and female mice intraperitoneally injected with combination of 5- HTP (100 mg/Kg / mouse body

Photo Weight and (20 mg /Kg mouse body weight) 20 minutes before whole body exposure to 10 Gy Gamma radiation, photographed 12 – 14 days after exposure. The animals show normal body size, smooth hair and no sign of emaciation. **Photo No. 7.** Shows animal survived the lethal dose of 10 Gy Gamma at stage of recovery, their smooth and shiny, with no skin abnormality.

DISCUSSION

Although the development of protective agents against harmful radiations has been a subject of a large number of investigation for decades, the more effective and less toxic radioprotectors and radiomitigators for human remain an unsolved problem. However, it is well agreed upon that ionizing radiation-induced cellular damage is primarily attributed to free radicals. Therefore, free radical scavengers are proposed to be promising as potential radioprotectors (Obrador et al., 2020). In the present study, two compounds were purposely used. Firstly, 5 - HTP which is known as a potential antioxidant and free radical scavenging compound that can neutralize free radicals (Cadenas et al., 1989, Keithahn and Lerchi, 2005, Maffei et al., 2021). Secondly, 5 - HTP is widely used in folk medicine as an aid to relieve the symptoms of anxiety, depression, fibromyalgia, insomnia, chronic headaches, premenstrual syndrome, and binge-eating related to obesity, attention deficit disorder, Parkinson's disease (Chase et al., 1972, Cangiano et al., 1992, Guyton and Hall, 1996, Murray, 1998, Kamran et al., 2016, Meloni et al., 2020)). Thirdly, 5 -HTP is commercially available from the seeds of an African plant, *Griffonia simplicifolia*. Fourthly, as far as safety concerned, 5 - hydroxytryptophan (5 - HTP) is an over-the-counter dietary supplement sold under the brand name "oxitriptan" and sold as oral capsule 100 mg and 50 mg. oral tablet. (Multum, 2025) The second compound used in this study was AET (S - (2 - amino ethyl) isothiuronium bromide hydrobromide. This compound is known to mitigate radiation effect at concentration (400 mg / Kg mouse body mass; which is close to its LD₅₀ (Guyton and Hall, 1996, Murray, 1998 Kamran et al., 2016). Benova, 1976, reported that AET at a concentration of 166 mg Kg mouse body weight ensuring 50 % (LD 50) survival in lethally irradiated animals. The photograph in Fig. 1. Shows an irradiation device specially designed to accommodate 5 animals simultaneously and ensures equal radiation dose for each animal. In our study, the amount of AET was reduced to only 20 mg / Kg /mouse body weight when combined with 5 - HTP (100 mg / Kg body mouse body weight) ensured 100 % survival in lethally irradiated mice. The survival was dropped to about 40 % when the amount of 5 -HTP decreased to 25 and 50 mg / Kg body weight (Fig. 2). Data in Fig. 2 also show that when no either above compounds were used, the survival among the irradiated animals was dropped to 5% only. All mortalities occurred within 12 – 14 days after irradiation, and intraperitoneal administration of sterilized distilled water have no effect on survival.

CONCLUSION

Nowadays, 5 - HTP equally used as a drug and a natural dietary supplement. It can easily cross the blood – barrier and effectively increases serotonin synthesis in the brain. Besides, the antioxidant properties of 5- HTP can be utilized as free radical scavenger since exposure to ionizing radiation usually result in release of dangerous free radicals. Finally, the synergistic radio protective

property of 5 -HTP with AET found in this study is another advantage. This study has also showed the mitigation of harmful effect of high dose of radiation on hair loss (alopecia) and skin embedment. which may

have positive clinical application in radiotherapy. It is worthy to mention that no alopecia from radiotherapy can be completely prevented.

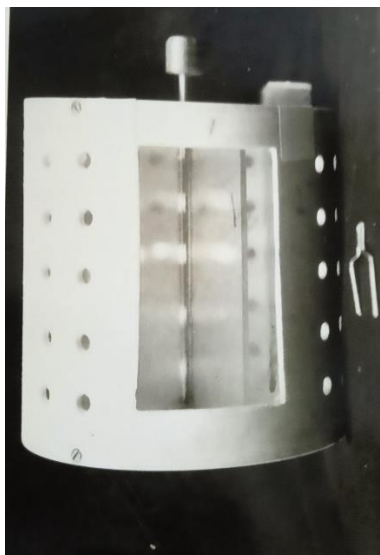


Photo No. 1: Irradiation chamber specifically designed to accommodate 5 animals simultaneously and ensure receiving equally and uniform dose of whole body irradiation.



Photo No. 2: male and female mice without any treatment, photographed 12 -14 days, the mice show shiny hair and normal body size, and skin embedment.



Photo No. 3: Shows male and female, mice intraperitoneally injected with distilled sterilized water to serve as control and photographed 12 -14 days later to serve as control.



Photo No. 4: BALB/c male mice (2) and female (3) exposed to 8 and / or 10 Gy gamma radiation, photographed 12 days after exposure. The animals show the typical marked radiation syndrome in male and female mice respectively as a result of whole body exposure to 8 and / or 10 Gy of gamma radiation. It can be seen that the animals are apathetic; their hair is ruffled and the embedment is reduced as a result of the general emaciation.

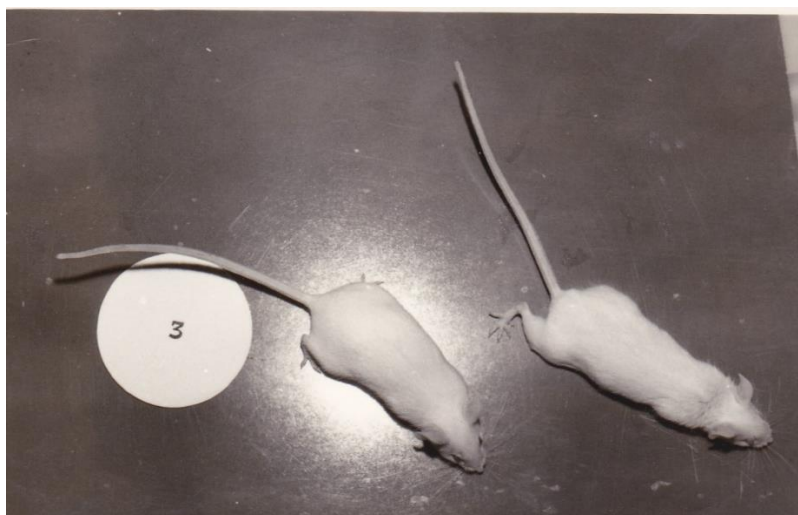
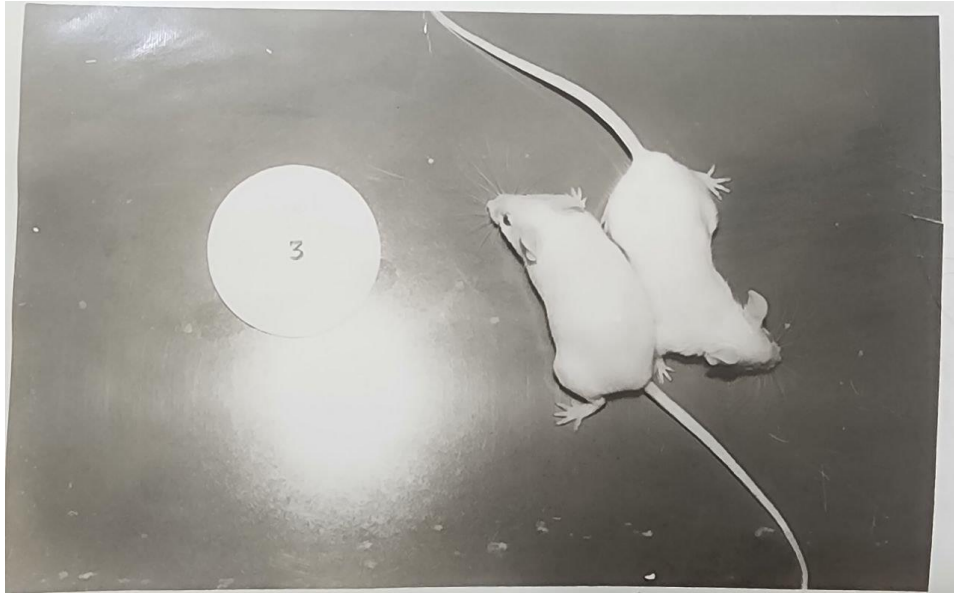


Photo No. 5: Male and female mice intraperitoneally injected with 5 –HTP and / or combination 5 – HTP and photographed 12 – 14 days after (100 and 20 mg AET / Kg body weight) 15- 20 minutes before whole body exposure to 8 and /or 10 Gy Gamma radiation; and photographed 12 – 14 days after irradiation. It can be seen

the animals are active, no sign of weight reduction and their hair is shining - smooth hair with no sign of body size reduction.



No. 6: Male and female mice intraperitoneally injected with combination of 5- HTP (100 mg/Kg / mouse body Photo Weight and (20 mg /Kg mouse body weight) 20 minutes before whole body exposure to 10 Gy Gamma radiation, photographed 12 – 14 days after exposure. The animals show normal body size, smooth hair and no sign of emaciation.

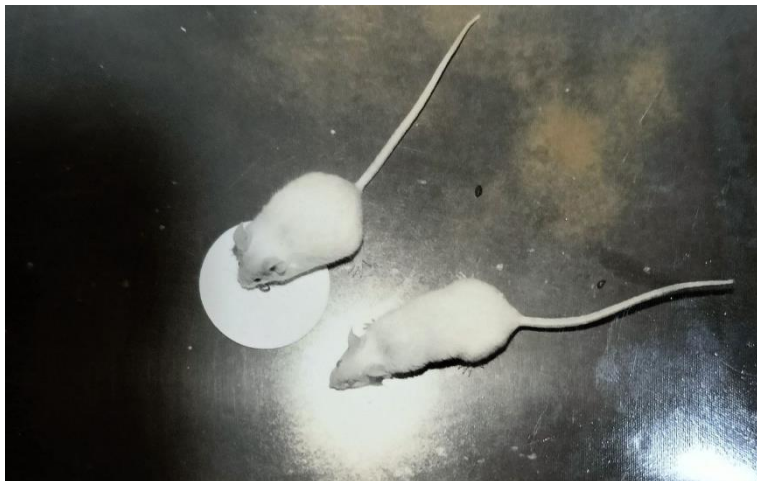


Photo No. 7: Shows animal survived the lethal dose of 10 Gy Gamma at stage of recovery, their smooth and shiny, with no skin abnormality.

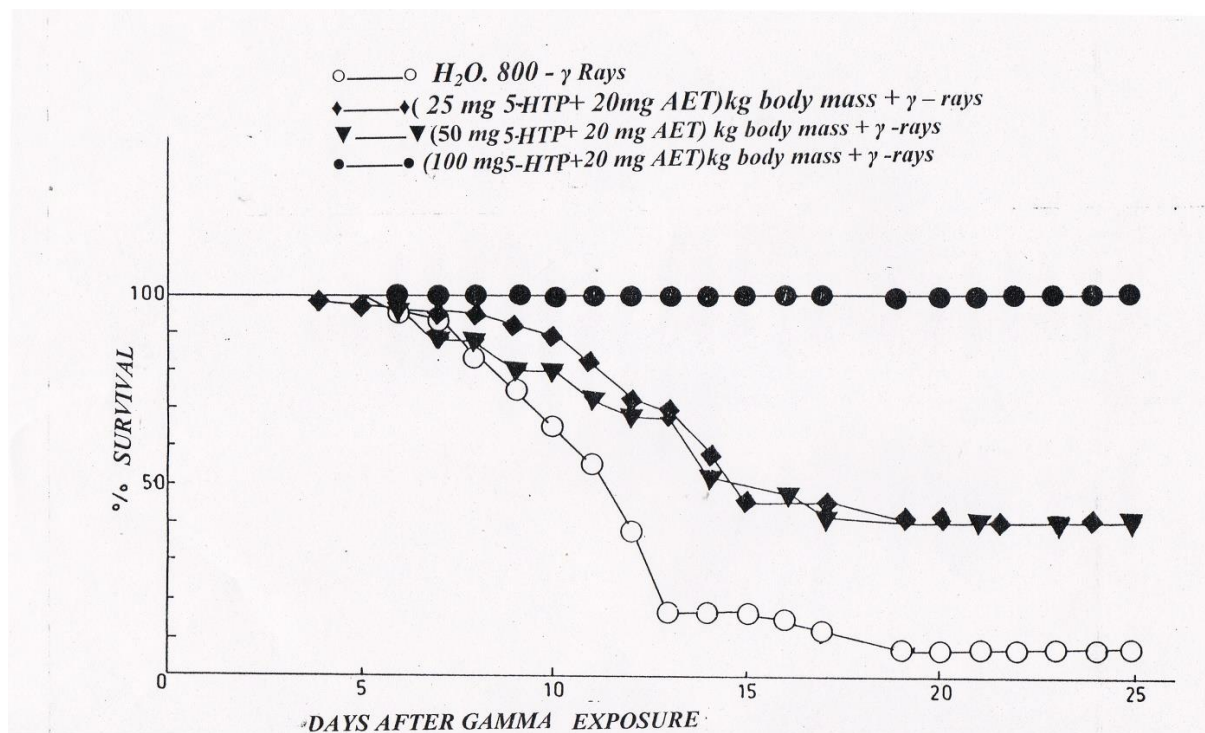


Fig. 1: Effect of different treatments on survival of mice.

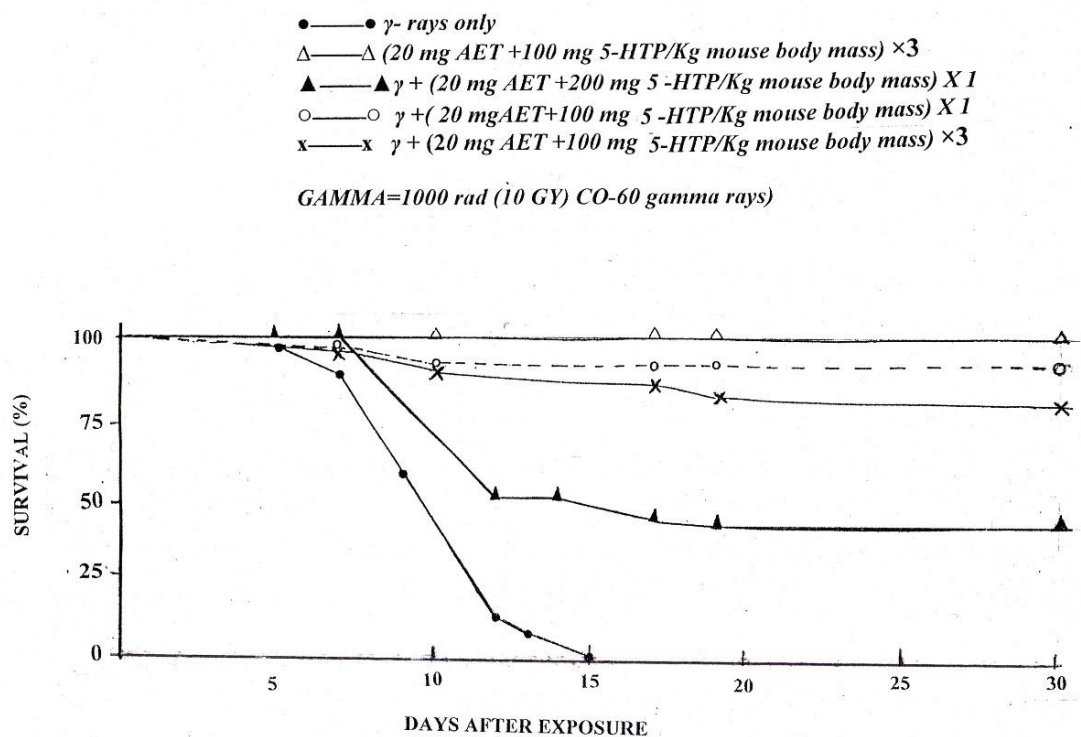


Fig. 2: Effect of 10 Gy whole body Gamma radiation on different treatments on mice survival on mice survival.

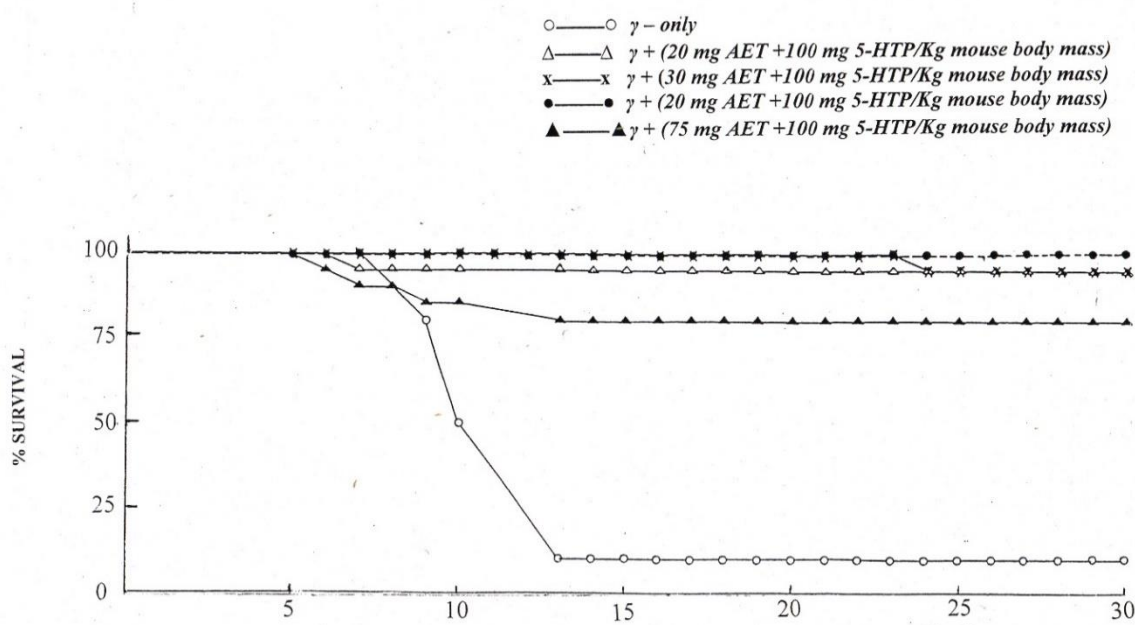


Fig. 3: Effect of concentrations of AET in combination with a single concentration of 5 – HTP on mice exposed to 8 Gy whole body gamma irradiation.

REFERENCES

- Al – Wandawi H. Enhancement of anti-radiation potential of some aminothiols by - β -carotene. *Annals of Nutrition & Metabolism*, 2003; Vol. 47, No.3 – 4: 176 – 180.
- Benova D. Radioprotective effectiveness of toxicity of ATP, AET, and serotonin applied individually or simultaneously to mice II. Dose depending protection by single agents. *Strahlentherapie* .1972; 151(3): 274 – 7.
- Bhat, K., Medina, P., He, L., Zhang, L., Saki, M., Ioannidis, A., et al. (2020).1-[(4-Nitrophenyl) sulfonyl]-4-phenylpiperazine Treatment After Brain Irradiation Preserves Cognitive Function in Mice. *Neuro Oncol.*, 22: 1484–1494. doi:10.1093/neuonc / noaa095.
- Billings PC. Romero – Weaver, AL, Kennedy AR. Effect of gender on the radiation sensitivity of marine gravitational and space research, 2014; 2(1): 25–31.
- Birdsall TC. 5-Hydroxytryptophan: A clinically-effective serotonin precursor. *Altern Med Rev.*, 1998; 3(4): 271–280.
- Cadenas E, Simic MG, Sies H. Antioxidant activity of 5 – hydroxytryptophan, 5 – hydroxyindol, and DOPA against microsomal lipid peroxidation and its dependence on vitamin E. *Fre Radic Res Commun.*, 1989; (1: 11 –17).
- Cangiano C, Ceci F, Cascino, A. Del- Ben, M.1992.Eating behavior and adherence to dietary prescription in obese subjects treated with 5 – HTP. *Am. J. Clin. Nutr.*, 1992; (56): 863–86.
- Caruso I, Puttini PS, Cazzola M, Azzolini V. Double-blind-study of 5-hydroxytryptophan versus placebo in the treatment of primary fibromyalgia syndrome. *J. Int. Med Res.*, 1990; 18: 201–209.
- Chase TN, Ng LK, Watonga AM. Parkinson's disease modification by 5 – hydroxytryptophan. 1972; 22(5): 479 – 84.
- Di Viesti GV, Zavatti M, Zanolli P. Anxiolytic-like effect of Griffonia simplicifolia baill. Seed extract in rats. *Phytomedicine*, 2011; 18: 848–851.
- Cummings JL. II.B.5- HTP (5-Hydroxytryptophan) In: *Psychotherapy* 2002.
- Dragaric I G. and Dragaric, Z. D. The radiation chemistry of water, page 265, Academic Press, New York, 1971.
- El - Shanshoury H, El – Shanshoury G, Abaza A. Evaluation of low dose ionizing radiation effect on some blood components in animal model. *Journal of Radiation and Applied Sciences*, 2016; 9(3): 282–293.
- Esposito M., Precenzano F., Sorrentino M., Apollo D., Carotenuto M. A medical food formulation of Griffonia simplicifolia/magnesium for childhood periodic syndrome therapy: An open-label study on motion sickness. *J. Med. Food*, 2015; 18: 916–920. doi: 10.1089/jmf.2014.0113. [PubMed] [CrossRef] [Google Scholar]
- George S, Chuttani K. and Basu S.k.1992. Radiation protection of male fertility in mouse and rat by combination of 5 – hydroxy – L – tryptophan. *Acta Oncologica*, 31(6): pages 669 – 672.
- Gomes P, Soares – da – Siva P. 1999. DOPA transport properties in an immortalized cell line rat capillary cerebral and epithelial cells *Brain Res.*, 829(1 – 2): 143150 doi: 10. 1016 / 50006 (99) 01387 – 6 PMID 39668.

17. Greenberger J S. and Epperly, MW. Radioprotective gene therapy (review article). *Gene Therapy Mol. Biol.*, 2004; (8): 31 - 44.
18. Gudkov, SV, Popova, NR, and Bruskov 2015. Radioprotective substances: History, trends and prospects. *Biophysics*, 60(4): 659 – 667.
19. Guyton, AC. and Hall, JC. Text book of medical physiology, 9th edn. 1996, W. B. Saunder, Philadelphia, USA.
20. Hölund E, Överli, Winberg S. Tryptophan Metabolic Pathways and Brain Serotonin Activity: A Comparative Review. *Sec. Experimental Endocrinology*, 2019; 10. <http://doi.org/10.3389/fendo.2019.00158>.
21. Jacobs, GP. 1998. A review on the effects of ionizing radiation on blood and blood components. *Radiation Physics and Chemistry*, 53(5): 511- 523.
22. Jawerth, N. Five years after Fukushima: making nuclear power safer. IAEA office of information and communication, 10 the march, 2016.
23. Kamran, MZ., A. Ranjan, N. Kauri, S. Sur, and V. Tandon. *Medical Research Reviews*, 2016; 36(3): pages 461 -493.
24. Keithahn C, Lerchi A, 5 – hydroxytryptophan is a more potent in vitro deoxy radical scavenger than melatonin or vitamin C. *JFR (Journal of final research)*, 2005; (38) (i), pages: 62 – 66.
25. Kuruba V and Gollapalli p. Natural radioprotectors and their impact on cancer drug discovery. *Radiat Oncol J.*, 2018; 36(4): 265 – 275.
26. Maffei ME. 2021. 5 – Hydroxytryptophan (5 – HTP): Natural Occurrence, Analysis, Biosynthesis, Biotechnology, Physiology and Toxicology. *Int J Mol Sci.*, 2021; (1): 181.
27. Maks, C J., Steven Wan, Jeffrey, H., et al., 2011. Analysis of white blood cell counts in mice after Gamma or proton exposure. *Radiation Research*, 176(2): pages: 170 - 176. doi: <http://dx.doi.org/10.1667/RR2413.1>.
28. Meloni M, Puligheddu M, Sanna F, Cannas, Farris R, Tronci E, Figorilli, Defazio G, Carta M. Efficacy and safety of 5 –hydroxytryptophan on levodopa – induced motor complications in Parkinson’s disease; A: A preliminary finding. *Neurol Sci.*, 2020 Aug 15; 415: 11.
29. Medina JJM, Naso LG, Perez AL, Rizzi NBO, Valcarcel M, Saladoc et al. Synthesis, characterization, theoretical studies and biological (antioxidant, anticancer toxicity and neuroprotective) determinations of copper (II) complex with 5 – hydroxytryptophan. 2019, *Biomed Pharmacology*, 111: 414- 426.
30. Micewicz ED, Iwamoto KS, Patikan JA, Nguyyen C. et al. The aftermath of surviving acute radiation hematopoietic syndrome and its mitigation. *Radiat Res.*, 2019; 191(4): 223 -334.
31. Multum C. 5 – hydroxytryptophan, medically reviewed by Drug.com on Aug 4; 2025.
32. Murray, NDM. 1998. 5 – HTP – The natural way to overcome depression, obesity, and insomnia. Bentom Books, New York.
33. Nair, Ch K K, D K. Parida and T. Nomura., 2001. Radioprotectors in radiotherapy, *J. RADIAT.RES.*, 2001; 42: 21 – 37.
34. Nair CKK, Parida DK. and Nomura, T. Radioprotectors in radiotherapy. *J. RADIT.RES.*, 2001; 42: 21 -37.
35. Nenot J C. One decade after Chernobyl: Summing up the consequences of the accident. *Proceeding of an international conference, Vienna*, 8(12): April, 1996.
36. Obrador E, Salvador R, Villescusa, J, Soriano JM. Radioprotection and radiomitigation from the Bench to Clinical Practice. *Biomedicines*, 2020; 8(11): 461.
37. Ribeiro C.A.F. L – 5 – hydroxyl tryptophan in the prophylaxis of chronic tension – type: a double - blind randomized, placebo – controlled study. *Headache*, 2000; 40: 451- 6.
38. Rondanelli M, Opizzi A, Faliva M, Bucci M, Perna S. Relationship between the absorption of 5-hydroxytryptophan from an integrated diet, by means of Griffonia simplicifolia extract, and the effect on satiety in overweight females after oral spray administration. *E Weight Discords. Stud. Anorex. Bulim. Obes.*, 2012; 17: E22–E28. [[PubMed](#)] [[Google Scholar](#)].
39. Roth W, Zadeh K, Vekariya R, Ge Yong, Tryptophan Metabolism and Gut – Brain Homeostasis. *Int. J. Mol.Sci.*, 2021; 22(6): 2973.
40. SIPRI (Stockholm international Peace Research Institute; Yearbook, 2023; 2025.
41. Tanaka S I. Accident at the Fukushima Dai – ichi nuclear power station of TEPCO- outline & lesions learned. *Proc Jpn Acad Ser B Phys Biol Sci.*, 2012; Nov 9: 471 – 484.
42. Thokchom SK, Indracanti N, Khanna A, Indrāvati PK. Safety evaluation of 5 – hydroxytryptophan and S – (amino ethyl) isothiuronium bromide hydrobromide on rodent lungs. *Indian J Pharmacol.*, 2024; 56(1): 28 – 36.
43. Thomas E.D. Bone marrow transplantation, past, present, and future. Nobel lecture, 8: 1990.
44. UNSCEAR, 2008, Vol. II, scientific appendixes, D, and E.
45. van Praag, HM, and Leusus, C. Monoamine precursors in the treatment psychiatric disorders. *Nutrition and Brain*, 7: Wartman, R.J. and Wartman, J.J.(eds). New York, Raven Press, 1986.
46. Weiss, JF. And Landauer. Radioprotection by antioxidants. *Ann. Rev. NY Acad.Sci.*, 2000; 899: 44- 60.
47. Weiss, GF. Phamalogical approaches to protection against radiation - induced lethality and other damage.
48. Weiss, J.F. and Landauer, M.R. History and development of radiation – protection agents. *Int. J. Radiat. Biol.*, 2009; 85: ol No.7: 539 -573.

49. World Health Organization (WHO): Chernobyl at 25th anniversary questions – April – 2011. Response in depression and mania. *Arch. Gen. Psychiatry.*, 1984; 41: 366–374. doi: 10.1001/archpsyc.1984.01790150056009. [PubMed] [CrossRef].